Surface Tension and Viscosity of Quasicrystal-Forming Ti-Zr-Ni Alloys

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Quasicrystals are a symmetric but non-periodic arrangement of atoms, discovered in 1984 in Al-Mn alloys and since in many different alloy systems, including Ti-based and Zr-based systems. Quasicrystals have unique physical and electronic properties that make them promising for such diverse applications as infrared sensors, non-stick cookware, and hydrogen storage.

Quasicrystal-forming systems seem ideal to test Frank's hypothesis that the undercoolability of liquid metals is caused by significant icosahedral short range order in the liquid. These icosahedral clusters are incompatible with crystalline periodicity; however, icosahedra may form a quasicrystalline phase. The ordering in the liquid should increase as undercooling increases, and this clustering should be reflected in a change in thermophysical properties of the liquid.

The surface tension and viscosity of quasicrystal-forming Ti-Zr-Ni alloys were measured over a range of temperature, including both stable and undercooled liquids. Because these alloys are highly reactive and the quasicrystal formation is suppressed by oxygen, the tests were performed in high vacuum ($\sim 10^{-7}$ Torr) using NASA/MSFC's Electrostatic Levitation Facility (ESL). ESL is a containerless technique which allows processing of samples without contact, greatly reducing contamination and increasing access to the metastable undercooled liquid.

The measurements were made with the oscillating drop technique. The levitation field is modulated at a frequency near the resonant frequency of the levitated liquid drop, exciting surface oscillations. The resonant frequency is determined by the surface tension of the drop. When the excitation is interrupted, the oscillations decay due to the effect of viscosity. The oscillations are monitored by high-speed digital video, and image processing yields the amplitude vs. time curve, which is fit to determine the resonant frequency and damping time.

The measured viscosity is typical of glass-forming alloys of similar composition to the quasicrystal-forming alloys studied here, while the surface tension shows an anomaly at deep undercoolings.